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DIAMETER GROWTH, SURVIVAL, AND VOLUME ESTIMATES FOR MISSOURI TREES

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ABSTRACT.—Measurements of more than 20,000 Missouri trees were summarized by species and diameter class into tables of mean annual diameter growth, annual probability of survival, net cubic foot volume, and net board foot volume. In the absence of better forecasting techniques, this information can be utilized to project short-term changes for Missouri trees, inventory plots, stands, or forests.

KEY WORDS: Cubic foot volume, board foot volume, crown class, mortality.

North Central Forest Experiment Station researchers are assembling the data necessary to develop a system of growth and mortality simulation models for the Central States similar to those used for the Lake States species in the Stand and Tree Evaluation and Modeling System (STEMS).[1] Much of the data for this research has come from Missouri. In fact, nearly 3,000 forest inventory plots were measured when Missouri's forests were surveyed in the early 1970's (Spencer and Essex 1976). Two thirds of those plots were remeasurements of plots established in 1959.[2] These plots include data for more than 20,000 trees in Missouri.

The large quantity and wide distribution of the Missouri data make them of special interest as a source of individual-tree growth, mortality, and volume information. Summarized here is information concerning mean annual diameter growth, mean annual survival rate, and mean cubic-foot and board-foot volume by species group and diameter class. In the absence of more sophisticated techniques, these summaries are useful guides for estimating growth, mortality, and volume for Missouri trees and stands.

The summary of diameter growth by species group and diameter class (table 1) shows that mean annual diameter growth rates ranged from well below 0.1 inch (0.3 cm) per year for hickory to more than 0.3 inch (0.8 cm) per year for cottonwood. The mean annual diameter growth for all trees was 0.115 inch (0.292 cm). Averaged across all species, diameter growth increased with increasing diameter, but this trend was not consistent for each species group individually. Some of the variation in the diameter growth rates both among and within species groups is due to the different number of observations and different sampling error associated with each of the mean values reported. Summaries of diameter growth by crown class, diameter class, and species group clearly show the faster growth associated with trees from dominant and codominant crown classes (table 2).

The mean annual survival rate for the sampled trees was 98.4 percent (table 3). Mean annual sur-

[1]*Belcher, D. M.; Holdaway, M. R.; Brand, G. J. A description of STEMS, the Stand and Tree Evaluation and Modeling System (in prep.).*

[2]*Includes 226 plots from the Mark Twain National Forest that were established in 1971 and remeasured in 1977.*

vival rates were generally lower for trees less than 5 inches in diameter or greater than 15 inches in diameter than they were for trees 6 to 14 inches in diameter.

Net cubic-foot and board-foot volumes by species group and diameter class were averaged from more than 13,000 individual tree observations (tables 4 and 5). Gross tree volumes were calculated using Stone's equation[3], which is a function of observed breast height diameter, merchantable height, and top diameter outside bark. Gross volume estimates were corrected for differences in bark thickness among species; field estimates of cull volume were applied to these gross volume estimates to arrive at net tree volume.

Minimum acceptable top diameters outside bark were 4.0 and 9.0 inches for poletimber and sawtimber, respectively. However, poor form often lowered merchantable height below where the minimum top diameter occurred, so top diameters at merchantable height generally increased as diameter increased.[4]

Tables 1–5 can be used to estimate average tree-by-tree growth and survival for Missouri inventory plots. Such projections require a tree list that itemizes species, diameter, and perhaps crown class for a representative sample of trees from the stand or stands being considered. Alternatively, total stand growth can be estimated using the stand table projection techniques described by Husch *et al.* (1972). Stand table projections require a summary of the number of trees by species and diameter class.

Although simple inventory projections can be implemented using only a pencil, some paper, and a hand calculator, they are also readily computerized. For example, Moser (1980), Mawson and Mack (1980), Harrison and Rauch (1979), Pelz (1978), and Ek *et al.* (1973) all describe computerized forest data processing programs that summarize current and projected stand and stock tables from forest inventory data. Growth estimates in those programs are usually derived from increment cores taken during the inventory or from user-supplied growth-rate tables. A similar system could be adapted for use in Missouri with the data in tables 1–3 providing the basis for estimating growth and mortality. Increment core measurements could be used to adjust the growth rate tables to reflect local conditions.

For any of the above projection techniques, tree and stand volume can be estimated from tables of mean tree volume (tables 4 and 5). Or, if all the necessary information were available, local volume equations, such as those prepared for Missouri by Hahn (1975) could be used.

When using the information in tables 1–5, remember that all reported values are averages that are subject to variablity and that some average values are based on very few observations. Furthermore, these values do not account for the effects of site quality, stand density, or stand manipulation on growth. Projections for a period much longer than the 11-year span encompassed by the basic data would be of questionable reliability. We anticipate that when the data from Missouri are merged with similar information from other Central States, it will be possible to formulate and calibrate a system of STEMS-type growth and mortality models applicable both in Missouri and in surrounding States. Such models would account for site quality, stand density, and inter-tree competition to provide more accurate and more biologically realistic projections of tree and stand growth than are possible from the information reported here.

[3]*A description of this function can be found in the appendix of: Raile, Gerhard K.; Smith, W. Brad.; Weist, Carol A. A Net volume equation for Michigan's Upper and Lower Peninsulas. Gen. Tech. Rep. NC-80. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station; 1982. 12 p.*

[4]*Tables of associated gross merchantable volumes, merchantable heights, and merchantable top diameters are available from the authors.*

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Table 1.--Mean annual diameter growth by species group and diameter class, Missouri[1]

(In inches)

Species group	Number of observations	Diameter class (inches at breast height) 1.0-2.9	3.0-4.9	5.0-6.9	7.0-8.9	9.0-10.9	11.0-12.9	13.0-14.9	15.0-16.9	17.0-18.9	19.0-20.9	21.0-22.9	23.0-24.9	25.0-26.9	27.0-28.9	29.0+	Average all classes
Shortleaf pine	912	.108	.118	.121	.131	.118	.125	.142	.129	.113	.110	--	--	--	--	--	.123
Baldcypress	17	--	--	--	--	.117	--	--	.192	.250	.237	.154	--	.273	.291	.138	.194
Eastern redcedar	247	.077	.103	.082	.100	.095	.077	.121	--	--	--	--	--	--	--	--	.090
Select white oak	4,207	.058	.087	.102	.117	.124	.124	.130	.125	.124	.111	.119	.125	.126	.143	.138	.111
White oak	3,691	.058	.089	.104	.120	.128	.125	.130	.125	.123	.110	.113	.116	.122	.103	.127	.112
Swamp white oak	111	.087	.114	.092	.111	.138	.165	.194	.141	.131	.139	.223	.153	.149	.268	.246	.140
Chinkapin oak	335	.066	.061	.080	.086	.071	.080	.090	.095	.129	.100	.115	.147	-	.093	.094	.082
Other white oak	2,868	.053	.070	.080	.093	.088	.088	.082	.083	.080	.065	.070	.085	.064	.071	.287	.080
Post oak	2,855	.051	.070	.080	.093	.087	.087	.080	.083	.076	.063	.070	.085	.064	.071	.175	.079
Select red oak	839	.090	.138	.140	.168	.158	.180	.179	.167	.161	.177	.175	.186	.194	.205	.245	.164
N. red oak	805	.090	.135	.139	.167	.158	.178	.177	.163	.164	.170	.175	.189	.194	.205	.245	.163
Other red oak	5,134	.086	.127	.146	.156	.159	.159	.155	.160	.157	.171	.157	.158	.177	.179	.173	.148
Scarlet oak	782	.084	.134	.158	.184	.189	.194	.198	.196	.165	.191	.149	.213	.212	--	.185	.168
Shingle oak	128	.255	.170	.164	.171	.209	.208	.215	.159	.217	.104	--	.105	.254	--	--	.182
Blackjack oak	690	.062	.092	.082	.095	.104	.111	.099	.089	.095	.164	.112	.150	--	--	--	.093
Black oak	3,409	.087	.132	.152	.158	.160	.157	.155	.159	.155	.162	.157	.151	.159	.179	.161	.150
Select hickory	1,848	.048	.070	.081	.091	.085	.101	.097	.093	.089	.114	.106	.147	.141	.293	.373	.078
Bitternut hickory	107	.083	.112	.117	.102	.071	.130	.205	--	.100	--	--	--	--	--	--	.106
Pignut hickory	590	.040	.059	.076	.081	.078	.091	.085	.078	.087	.090	.100	--	--	--	.373	.069
Shellbark hickory	120	.063	.076	.065	.102	.096	.103	.119	.090	.101	.157	.128	--	--	.150	--	.086
Shagbark hickory	356	.042	.064	.073	.090	.087	.118	.097	.114	.085	.092	--	.121	141	--	--	.079
Mockernut hickory	649	.048	.072	.083	.093	.085	.093	.079	.100	.075	.114	.070	.227	--	--	--	.077
Other hickory	618	.036	.056	.066	.071	.072	.081	.060	.116	.112	.082	--	.173	.091	--	--	.059
Black hickory	618	.036	.056	.066	.071	.072	.081	.060	.116	.112	.082	--	.173	.091	--	--	.059
Basswood	27	.143	.033	.073	.093	.146	.088	.023	.062	.231	.141	.114	--	.045	--	--	.105
Beech	12	--	.073	--	.154	.264	.250	--	--	.082	--	.064	.036	-	--	.345	.147
Hard maple	228	.049	.061	.072	.098	.133	.122	.112	.102	.193	.081	.038	.175	.254	.140	--	.092
Soft maple	181	.036	.161	.260	.197	.283	.228	.371	.459	.367	.291	.251	.204	.808	.227	.132	.214
Silver maple	116	.134	.233	.332	.210	.313	.216	.387	.459	.400	.291	.295	.431	.808	.227	.132	.303
Elm	585	.057	.086	.083	.110	.112	.111	.179	.119	.111	.157	.190	.149	.128	--	.246	.097
American elm	330	.069	.108	.093	.124	.109	.132	.221	.099	.114	.196	.217	.173	.093	--	.246	.113
Red elm	136	.045	.059	.089	.080	.128	.073	.096	.203	.082	.080	.149	.054	.250	--	--	.088
Black ash	5	--	--	.035	.130	--	--	--	.120	--	--	--	.040	-	--	--	.072
White & green ash	403	.067	.105	.138	.142	.151	.115	.126	.181	.131	.080	.133	.124	.231	.263	--	.124
White ash	193	.059	.098	.123	.117	.129	.101	.118	.166	.115	.031	.090	.210	--	--	--	.106
Green ash	210	.080	.113	.149	.169	.166	.122	.143	.191	.144	.097	.151	.081	.231	.263	--	.140
Sycamore	134	.182	.211	.234	.215	.211	.197	.143	.213	.300	.234	.268	.187	.108	.210	.186	.209
Cottonwood	26	.260	--	-	.588	--	.308	.850	.070	.577	--	.544	.366	.100	.070	.244	.341
Willow	38	.136	--	.387	.359	.276	.242	.238	.160	--	.133	.233	--	.110	--	.200	.232
Hackberry	136	.049	.161	.155	.143	.116	.172	.128	.246	.200	.092	.122	.195	--	.244	.069	.147
River birch	34	.069	.175	.354	.218	.220	.281	-	.236	.158	.248	.107	.157	--	--	.286	.217
Sweetgum	32	-	.103	.046	.168	.168	.173	.077	.086	.146	.043	.046	--	.118	--	--	.118
Black cherry	39	.231	.120	.167	.105	.147	.164	.066	.100	--	--	--	.160	--	--	--	.141
Black walnut	330	.122	.114	.115	.112	.123	.099	.115	.095	.084	.249	.131	.062	--	--	--	.112
Butternut	2	--	--	--	--	.131	--	.173	--	--	--	--	--	--	--	--	.152
Yellow-poplar	3	--	--	--	.336	--	.291	--	--	.182	--	--	--	--	--	--	.270
Other hardwoods	855	.050	.081	.103	.148	.147	.140	.124	.120	.098	.098	.084	.117	.156	.042	.250	.084
Sassafras	107	.052	.067	.067	.058	.110	--	--	--	--	.100	--	--	--	--	--	.058
Noncommercial species	138	.048	.082	.062	.186	.111	--	--	--	--	--	--	--	--	--	--	.060
All softwoods	1,176	.094	.111	.110	.127	.116	.121	.141	.137	.122	.183	.154	--	.273	.291	.138	.117
All hardwoods	18,722	.059	.093	.110	.126	.131	.131	.131	.136	.134	.136	.139	.148	.147	.169	.188	.115
All species	19,898	.061	.094	.110	.126	.130	.131	.132	.136	.134	.137	.139	.148	.148	.171	.185	.115

[1]Growth rates were calculated using as many observations as were available; some rates are based upon one observation. Growth rates for each diameter class larger than 20 inches were usually computed using fewer than 2 percent of the total number of observations for a given species group.

[2]Indented entries designate individual species within a group that have 100 or more observations. Entries for the total species group are not indented and they include data for all species in that group regardless of whether information for one or more of the individual species in the group is reported separately.

Table 2.--Mean annual diameter growth by species group, crown class, and diameter class, Missouri[1]

(In inches)

Species group	Crown class	Number of observations	Diameter class (inches at breast height) 1.0-2.9	3.0-4.9	5.0-6.9	7.0-8.9	9.0-10.9	11.0-12.9	13.0-14.9	15.0-16.9	17.0-18.9	19.0-20.9	21.0-22.9	23.0-24.9	25.0-26.9	27.0-28.9	29.0+	Average all classes
Shortleaf pine	Dominant	92	.213	.200	.202	.195	.155	.143	.146	.114	.110	.110	--	--	--	--	--	.154
	Codominant	536	.270	.189	.140	.130	.106	.117	.127	.156	.143	--	--	--	--	--	--	.129
	Intermediate	105	.140	.109	.069	.063	.021	--	--	--	--	--	--	--	--	--	--	.092
	Overtopped	79	.057	.036	.035	.035	--	--	--	--	--	--	--	--	--	--	--	.046
Eastern redcedar	Dominant	27	.183	.388	.113	.114	.085	--	.121	--	--	--	--	--	--	--	--	.133
	Codominant	105	.120	.125	.080	.109	.108	.099	--	--	--	--	--	--	--	--	--	.101
	Intermediate	63	.078	.093	.060	.067	--	.045	--	--	--	--	--	--	--	--	--	.080
	Overtopped	52	.053	.061	.071	.072	.018	.008	--	--	--	--	--	--	--	--	--	.057
Select white oak	Dominant	995	--	.179	.170	.154	.160	.143	.150	.137	.132	.122	.138	.128	.133	.162	.150	.145
	Codominant	2,113	.152	.138	.124	.123	.121	.119	.120	.113	.115	.096	.097	.114	.102	.065	.041	.121
	Intermediate	609	.083	.082	.082	.077	.083	.066	.064	.073	--	.069	--	.138	--	--	--	.080
	Overtopped	489	.036	.043	.042	.053	.065	.037	.036	--	.023	--	--	--	--	--	--	.041
Other white oak	Dominant	704	.092	.166	.119	.122	.102	.095	.090	.093	.083	.067	.082	.096	.077	.087	.287	.097
	Codominant	1,400	.105	.098	.095	.097	.088	.086	.077	.073	.071	.061	.051	.040	.005	.038	--	.089
	Intermediate	457	.066	.054	.057	.057	.045	.058	.046	.052	.096	--	--	--	--	--	--	.057
	Overtopped	307	.031	.033	.034	.044	.082	.008	.020	--	--	--	--	--	--	--	--	.033
Select red oak	Dominant	315	.138	--	.198	.175	.180	.178	.185	.162	.177	.178	.194	.208	.197	.242	.271	.184
	Codominant	415	.146	.176	.150	.183	.152	.184	.179	.183	.146	.152	.134	.109	.179	.206	.140	.167
	Intermediate	73	.106	.111	.096	.120	.103	.142	.091	--	--	--	.040	--	--	--	--	.107
	Overtopped	32	.046	.079	.080	.025	.025	--	--	--	--	--	--	--	--	--	--	.054
Other red oak	Dominant	1,370	.208	.210	.240	.214	.195	.179	.173	.184	.167	.181	.164	.162	.188	.165	.170	.186
	Codominant	2,823	.153	.166	.157	.153	.153	.149	.142	.130	.139	.152	.138	.142	.130	.250	.184	.152
	Intermediate	635	.087	.091	.081	.091	.094	.086	.072	.065	.090	.079	--	--	--	--	--	.088
	Overtopped	300	.048	.066	.069	.072	.066	.040	.019	--	--	--	.136	--	--	--	--	.057
Hickory (All)	Dominant	418	.169	.142	.092	.113	.091	.115	.099	.100	.089	.123	.086	.134	.141	.150	.373	.105
	Codominant	932	.116	.115	.097	.092	.085	.084	.080	.089	.103	.081	.113	.227	.091	.436	--	.095
	Intermediate	509	.064	.060	.063	.052	.043	.040	.027	--	--	--	--	--	--	--	--	.060
	Overtopped	605	.026	.036	.040	.047	.021	.021	--	--	--	--	--	--	--	--	--	.031
Other commercial hardwoods (All)	Dominant	553	.265	.184	.201	.193	.176	.156	.171	.190	.184	.160	.195	.182	.183	.175	.203	.181
	Codominant	1,101	.109	.149	.160	.161	.152	.151	.142	.139	.148	.153	.147	.133	.044	.250	.125	.151
	Intermediate	584	.094	.105	.080	.094	.112	.092	.066	.103	.072	.269	.102	--	.140	--	.211	.096
	Overtopped	828	.043	.052	.059	.039	.102	.082	.103	.091	--	.106	--	--	--	--	--	.048

[1]Except for Eastern redcedar, includes only species groups with 800 or more observations.

Table 3.--Mean annual probability of survival by species group and diameter class, Missouri[1]

Species group	Number of observations	Diameter class (inches at breast height) 1.0-2.9	3.0-4.9	5.0-6.9	7.0-8.9	9.0-10.9	11.0-12.9	13.0-14.9	15.0-16.9	17.0-18.9	19.0-20.9	21.0-22.9	23.0-24.9	25.0-26.9	27.0-28.9	29.0+	Average all classes
Shortleaf pine	979	.971	.977	.991	.999	.999	.998	.995	1.000	1.000	--	--	--	--	--	--	.992
Baldcypress	22	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	.978
Eastern redcedar	262	.985	.997	.998	.997	.995	.991	--	--	--	--	--	--	--	--	--	.994
Select white oak	4,572	.980	.984	.992	.995	.997	.997	.996	.993	.992	.989	.994	.991	.983	.996	.988	.992
Other white oak	3,264	.967	.984	.991	.993	.995	.992	.993	.990	.991	.986	.980	.992	.992	-	-	.988
Select red oak	932	.975	.990	.987	.996	.993	.993	.989	.992	.993	.997	.995	.977	.974	.973	.992	.990
Other red oak	6,098	.954	.983	.987	.991	.991	.990	.986	.985	.981	.981	.975	.975	.978	.970	.973	.984
Select hickory	2,053	.981	.991	.994	.996	.994	.989	.991	.988	.989	.984	--	--	--	--	--	.990
Other hickory	723	.978	.983	.988	.993	.992	.988	.985	.981	--	--	--	--	--	--	--	.985
Basswood	31	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	.989
Beech	12	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1.000
Hard maple	249	.989	.991	.996	.997	.994	.988	.996	1.000	--	--	--	--	--	--	--	.992
Soft maple	224	.981	--	.985	.987	.990	.985	.972	.974	.981	--	--	--	--	--	.934	.979
Elm	1,315	.973	.964	.953	.935	.938	.911	.909	.878	.878	.864	.889	.861	.932	--	.842	.935
White & green ash	496	.965	.976	.976	.988	.994	.991	1.000	.993	.991	--	--	--	--	--	--	.982
Sycamore	158	.978	--	.982	.986	.981	.988	--	1.000	--	.988	--	--	--	--	--	.986
Cottonwood	37	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	.971
Willow	95	.902	--	--	--	.929	.979	.871	.866	--	--	--	--	--	--	--	.924
Hackberry	142	.991	.986	.994	.996	.996	.995	.983	--	--	--	--	--	--	--	--	.994
River birch	48	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	.974
Sweetgum	39	--	--	--	.990	--	--	--	--	--	--	--	--	--	--	--	.983
Black cherry	49	--	--	.984	--	--	--	--	--	--	--	--	--	--	--	--	.981
Black walnut	391	.965	.979	.979	.985	.991	.994	.983	1.000	.993	--	--	--	--	--	--	.986
Other hardwoods	1,107	.973	.976	.954	.983	.992	.980	.976	.991	.980	.981	--	--	--	--	--	.975
Noncommercial species	278	.940	.955	.931	--	--	--	--	--	--	--	--	--	--	--	--	.941
All softwoods	1,263	.977	.985	.993	.998	.998	.996	.995	.995	1.000	--	--	--	--	--	--	.992
All hardwoods	22,325	.970	.982	.986	.990	.991	.990	.987	.984	.981	.981	.977	.976	.974	.967	.953	.984
All species	23,588	.970	.982	.987	.991	.992	.990	.987	.984	.981	.981	.977	.976	.975	.967	.954	.984

[1]All values based upon at least 10 observations.

Table 4.--Average net merchantable volume per tree by species group and diameter class, Missouri

(In cubic feet)

Species group	Number of observations	Diameter class (inches at breast height) 5.0-6.9	7.0-8.9	9.0-10.9	11.0-12.9	13.0-14.9	15.0-16.9	17.0-18.9	19.0-20.9	21.0-22.9	23.0-24.9	25.0-26.9	27.0-28.9	29.0+
Shortleaf pine	889	2.36	5.12	9.58	14.70	20.22	29.81	38.42	52.21	--	--	--	--	--
Baldcypress	17	--	3.91	--	--	23.89	23.44	35.69	48.15	69.62	98.71	--	119.57	150.30
Eastern redcedar	192	2.00	4.50	8.19	11.58	17.46	20.28	--	--	--	--	--	--	--
Select white oak	3,291	2.42	5.12	9.29	14.69	19.99	27.22	35.67	41.89	51.96	65.25	68.26	66.34	117.61
Other white oak	1,545	2.34	4.75	7.95	12.08	16.87	22.39	27.69	38.69	46.75	50.63	60.88	0	223.62
Select red oak	501	2.72	5.13	9.16	14.72	21.21	29.05	35.69	47.43	71.88	73.50	102.69	129.61	134.26
Other red oak	3,704	2.38	5.22	8.99	14.01	19.91	27.32	36.17	44.52	52.11	66.42	89.05	95.51	128.01
Select hickory	568	2.23	5.01	9.04	15.20	22.10	31.16	37.70	49.75	75.08	89.70	--	153.04	192.91
Other hickory	614	2.13	4.89	8.76	14.22	20.63	28.05	42.67	57.08	63.10	94.72	44.76	--	--
Basswood	11	--	2.89	7.16	13.35	18.47	30.05	--	--	--	--	--	--	--
Beech	1	--	--	--	--	--	26.28	--	--	--	--	--	--	--
Hard maple	99	2.47	5.28	9.66	15.59	20.76	32.94	31.50	--	--	--	--	--	--
Soft maple	84	2.63	6.58	11.70	16.06	23.67	30.02	35.31	48.02	63.04	89.56	88.14	--	171.66
Elm	269	2.36	5.11	9.21	14.50	18.78	28.60	42.18	43.18	62.93	57.16	83.81	93.74	251.30
Black ash	7	2.59	--	--	8.21	--	--	--	--	45.59	46.60	--	--	--
White & green ash	226	2.45	5.19	9.54	13.48	21.58	27.18	35.68	44.35	46.52	59.69	86.05	--	183.56
Sycamore	222	3.10	7.10	12.41	19.05	28.45	42.63	48.57	60.52	76.82	110.12	126.48	137.22	226.41
Cottonwood	147	2.48	5.66	10.70	17.60	27.40	36.83	50.94	73.12	81.64	106.78	94.93	204.76	306.42
Willow	199	2.47	6.01	11.77	19.16	28.15	41.07	66.12	90.01	--	--	--	--	--
Hackberry	66	2.29	4.15	8.50	13.06	18.26	31.85	50.55	51.15	--	48.96	69.22	--	--
River birch	68	2.46	6.08	9.21	16.67	24.76	27.57	37.00	47.31	58.00	--	--	106.23	206.78
Sweetgum	23	1.28	4.84	10.30	14.04	11.90	31.82	35.97	--	--	--	--	155.90	--
Black cherry	15	2.19	4.77	6.01	13.92	20.63	30.58	31.98	--	--	--	--	--	--
Black walnut	290	2.38	5.04	8.68	13.62	18.94	22.90	34.78	40.75	38.93	61.55	77.35	--	--
Butternut	5	2.51	5.36	--	11.15	--	30.36	--	--	--	--	--	--	--
Yellow-poplar	1	--	--	--	--	--	--	--	--	--	--	--	--	161.46
Other hardwoods	185	1.94	4.89	9.15	12.93	19.05	24.16	33.30	50.32	60.78	83.77	36.45	51.95	135.64
All softwoods	1,098	2.24	4.99	9.39	14.50	20.07	28.78	38.06	51.05	69.62	98.71	--	119.57	150.30
All hardwoods	12,141	2.36	5.10	9.06	14.32	20.24	28.00	37.58	46.45	58.68	75.44	88.65	108.78	193.95
All species	13,239	2.35	5.09	9.09	14.33	20.23	28.02	37.59	46.57	58.82	75.68	88.65	109.32	191.42

Table 5.--Average net merchantable volume per tree by species group and diameter class, Missouri

(In board feet)[1]

Species group	Number of observations	Diameter class (inches at breast height) 11.0-12.9	13.0-14.9	15.0-16.9	17.0-18.9	19.0-20.9	21.0-22.9	23.0-24.9	25.0-26.9	27.0-28.9	29.0+
Shortleaf pine	260	81.66	121.27	177.48	230.71	345.00	--	--	--	--	--
Baldcypress	16	--	101.24	121.92	187.58	261.45	318.96	420.34	--	560.80	649.71
Eastern redcedar	17	61.56	103.03	99.69	--	--	--	--	--	--	--
Select white oak	1,607	70.85	96.20	128.73	165.47	203.42	233.85	301.81	357.57	349.69	432.54
Other white oak	510	59.27	84.12	106.41	136.87	180.25	226.24	262.26	271.98	--	956.81
Select red oak	315	68.12	109.12	142.78	192.30	245.13	337.80	354.89	355.68	737.87	687.68
Other red oak	1,672	70.06	100.78	140.89	181.34	224.22	270.15	310.92	358.34	395.92	495.27
Select hickory	201	75.58	102.81	149.34	185.03	285.16	363.38	412.56	--	606.67	805.94
Other hickory	154	71.77	96.01	142.66	193.36	261.54	378.31	510.11	236.45	--	--
Basswood	8	52.63	69.97	118.09	--	--	--	--	--	--	--
Beech	1	--	--	120.87	--	--	--	--	--	--	--
Hard maple	25	57.28	74.43	132.42	100.59	--	--	--	--	--	--
Soft maple	49	83.78	121.46	145.92	140.39	200.23	248.10	463.20	345.08	--	575.79
Elm	84	59.89	78.19	127.72	171.21	174.45	303.08	379.96	320.20	360.49	406.36
Black ash	3	32.85	--	--	--	--	146.56	212.05	--	--	--
White & green ash	92	51.71	89.08	135.79	172.19	176.27	218.65	414.11	616.18	--	1,028.90
Sycamore	165	72.64	122.69	190.64	230.46	293.40	415.32	581.99	521.26	861.20	1,084.95
Cottonwood	124	104.25	147.98	194.50	264.05	378.71	437.22	542.86	578.25	955.59	1,449.77
Willow	116	85.29	129.94	195.32	290.05	392.42	--	--	--	--	--
Hackberry	25	59.93	89.12	149.29	189.64	290.95	--	190.09	458.79	--	--
River birch	36	80.62	110.09	127.59	213.86	369.69	354.89	--	--	378.94	745.62
Sweetgum	13	64.51	100.46	157.35	275.52	--	--	--	--	888.43	--
Black cherry	7	59.08	78.90	135.69	160.24	--	--	--	--	--	--
Black walnut	133	59.22	88.47	115.40	179.65	191.22	180.07	359.08	428.27	--	--
Butternut	2	56.44	--	113.57	--	--	--	--	--	--	--
Yellow-poplar	1	--	--	--	--	--	--	--	--	--	326.50
Other hardwoods	82	60.49	101.70	145.88	175.23	256.51	341.35	313.54	446.73	238.74	819.32
All softwoods	293	80.42	119.68	168.87	224.96	321.13	318.96	420.34	--	560.80	649.71
All hardwoods	5,425	68.92	98.71	137.85	183.87	231.03	290.74	370.51	397.85	538.92	815.53
All species	5,718	69.83	99.66	138.89	185.03	233.46	291.11	371.03	397.85	540.01	805.91

[1]International 1/4-inch rule.

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